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DIAGNOSTIC CHARACTERS IN THE JUNGERMANNIACEAE.

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If one were asked to describe in a few words the general characteristics of the mosses the task would be comparatively easy, at least so far as the gametophyte is concerned. Throughout the entire group this consists of a leafy stem, and the leaves although exhibiting considerable diversity in form, in texture and in the peculiarities of the margin, are never deeply

EXPLANATION OF PLATE V.

Fig. 1. *Kantia Trichomanis*, from above. Fig. 2. The same, from below. Fig. 3. *Odontoschisma prostratum*, from above. Fig. 4. *Plagiochila asplenoides*, from above. Fig. 5. Diagram to illustrate the attachment of succubous leaves, the dotted lines representing the lines of attachment and the arrow the direction of growth. Fig. 6. Diagram to represent the attachment of incubous leaves. Fig. 7. *Cephalozia connivens*, from above. Fig. 8. *Lophocolea bidentata*, from below. Fig. 9. *Kantia Sullivantii*. from above Fig. 10. *Bazzania trilobata*, from above. Fig. 11. *Lepidozia reptans*, from below. Fig. 12. *Marsupella emarginata*, from above. Fig. 13. *Archilejeunea clypeata*, from below. Fig. 14. *Frullania Brittoniae*, from below. Fig. 15. *Porella platyphylla*, from below. Fig. 16. *Diplophylleia apiculata*, from above. Fig. 17. Diagram to illustrate the attachment of complicate leaves which are neither incubous nor succubous. Fig. 18. Diagram to illustrate the attachment of complicate and incubous leaves. Fig. 19. Diagram to illustrate the attachment of complicate and succubous leaves. Fig. 20. *Harpanthus scutatus*, underleaf. Fig. 21. *Lophozia barbata*, underleaf (after Warnstorf); bifid underleaves also occur in this species. Fig. 22. *Cephalozia connivens*, bract. Fig. 23 *Frullania Brittoniae*, bract. Fig 24. Diagram representing a radial section through an archegonial branch and young sporophyte in the genus *Lophocolea*: *S.* sporophyte; *Cal.* calyptra; *Per.* perianth; *Br.* bract. Fig. 25. Diagram representing a cross-section of the perianth in the same genus, *i. e.*, an epigonianthous perianth. Fig. 26. Diagram representing a cross-section of the perianth in the genus *Plagiochila*. Fig. 27. Diagram representing a cross-section of the perianth in the genus *Cephalozia*, *i. e.* a hypogonianthous perianth. Fig. 28. Diagram representing a cross-section of the perianth in the genus *Scapania*. Fig. 29. Diagram representing a radial section through an archegonial branch and young sporophyte in the genus *Marsupella*: *Pg.* perigynium; other references as in Fig. 24. Fig. 30. Diagram representing a radial section through the pendent perigynium and young sporophyte in the genus *Kantia*.

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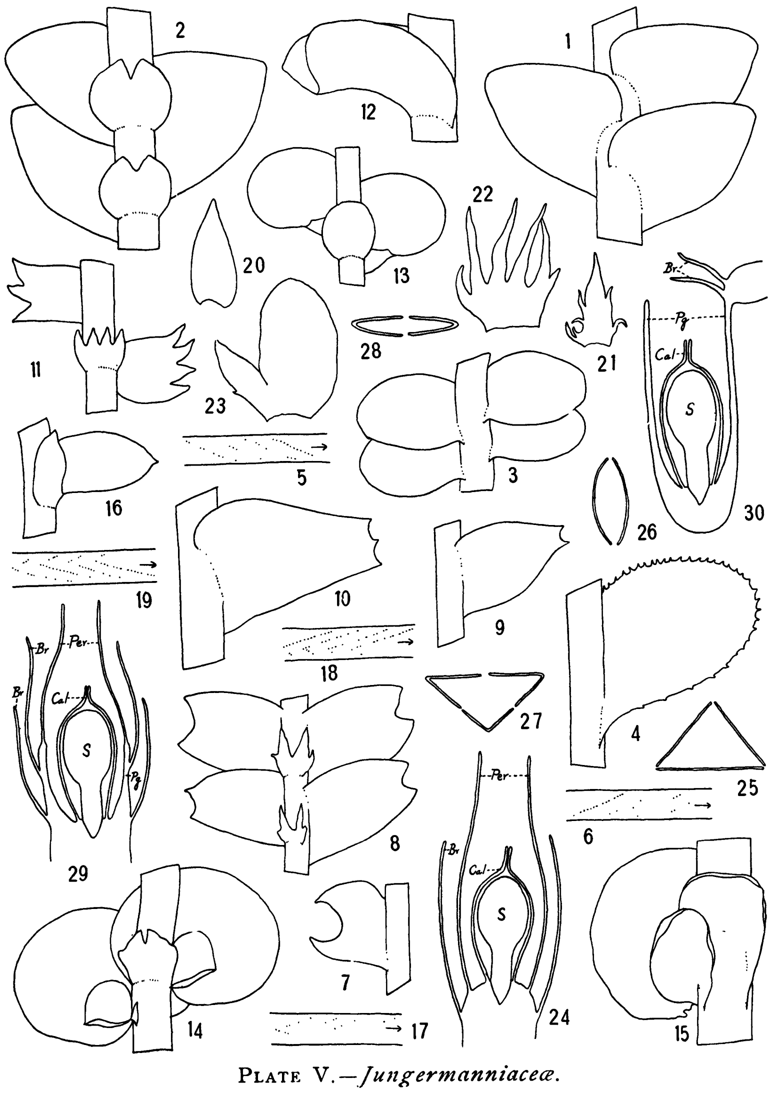

Plate V.—*Jungermanniaceæ.*

lobed or cleft and never show very marked differences in the various parts of the plant, even when the stem and its branches are prostrate and closely adherent to the substratum.

With the Hepaticae, on the other hand, the task would be much more difficult. The gametophyte here exhibits the greatest variety in different families. It is sometimes a flat thallus without any indication of leaves, sometimes a thallus-like stem with rudimentary leaves, sometimes a more or less cylindrical stem with distinct leaves; and these various types are connected by intermediate conditions. In the thallose forms the cell-structure is sometimes uniform throughout or nearly so, and sometimes shows a high degree of differentiation; here again there are intermediate conditions. Both thallose and leafy species are almost always prostrate and show marked differences between the upper and lower portions. In other words they are "dorsi-ventral." In the thallose forms the dorsiventrality manifests itself in differences in cell-structure; in the leafy forms in differences between the leaves.

In the eastern United States nearly three fourths of our Hepaticae are leafy and belong to the family Jungermanniaceae, sometimes spoken of as the "scale-mosses," and we will confine our attention to these. The scale-mosses may usually be distinguished at a glance from the true mosses by the prostrate habit to which allusion has just been made and by the fact that this habit usually brings about a distinctly flattened appearance for the whole plant, the leaves themselves as well as the stem being more or less appressed to the substratum. When we examine a plant carefully we find that the leaves are more regularly arranged than in most of the mosses; looking at a stem from above (*Fig. 1*) we see two distinct longitudinal ranks of leaves spreading out on either side: looking at the same stem from below (*Fig. 2*) we can usually see a third rank of leaves, which are more or less appressed to the stem. The leaves in fact are in a spiral and conform to the one third arrangement. It will be seen at a glance that the leaves are not all exposed to the same external conditions. Those, for example, in the two ranks which we saw from above, are turned toward the light, and are, therefore, well placed for carrying on photosynthesis; those in the third rank, however, are practically cut off from the light. Probably this difference in environment has been a potent factor in bringing about a diversity in the leaves, those in the third rank being different in form and usually much smaller than the others. For the sake of convenience in description, the leaves of the third rank are spoken of as "underleaves" while those of the other two ranks are called "side-leaves" or simply "leaves." In certain of our species the underleaves are so small that they can be demonstrated only by careful dissection; in a few species they are absent altogether. Even in the last case, however, the leaves are closer together on the upper surface of the stem than on the lower, so that they do not conform to the one half arrangement, which we would naturally expect with only two longitudinal ranks of leaves.

The leaves exhibit a much greater diversity of form than the underleaves, and this manifests itself in pecularities of the margin, in lobing or

division, in folding, and in the development of remarkable structures known as water-sacs. The simplest type of leaf is that which is undivided, although this is probably not the most primitive type. In this case the leaf varies in form from ovate to broadly rotund, and in all our northern genera is rounded or bluntly pointed at the apex (*Figs. 1-3*). The margin is commonly entire but is more or less toothed in certain species of *Plagiochila* (*Fig. 4*). The leaves here and throughout the group are sessile just as in the mosses, but the line of attachment instead of being transverse is usually oblique; sometimes the forward or apical end of this line is turned toward the substratum and sometimes away from it, these conditions being best shown by such diagrams as *Figs. 5* and *6*, the arrows indicating the direction of growth. These differences in the attachment of the leaves bring about differences in the way in which they overlap each other and are of the utmost importance in distinguishing certain genera. The condition seen in *Fig. 5* is known as succubous and is found in the common genera *Jungermannia*, *Nardia*, *Chiloscyphus*, *Plagiochila* (*Fig. 4*) and *Odontoschisma* (*Fig. 3*). The other condition is called incubous (*Fig. 6*), and is found in the common *Kantia Trichomanis* (*Figs. 1, 2*). The distinction between succubous and incubous leaves applies not only to species with undivided leaves but also to many of those with variously lobed or divided leaves.

Among lobed or divided leaves the simplest condition is found where only two apical teeth or lobes are present; sometimes the teeth are very minute and only one or two cells long; in other cases the divisions extend to the middle of the leaf or beyond. Among species with succubous leaves the bidentate or bilobed condition is found in the genus *Cephalozia* (*Fig. 7*), and in many species of *Lophocolea* (*Fig. 8*) and *Lophozia*; it is much rarer in species with incubous leaves but is clearly shown by *Kantia Sullivantii* (*Fig. 9*). In *Lophocolea heterophylla* the leaves show all gradations between the deeply bilobed and undivided conditions.

Tridentate and trifid leaves, quadridentate and quadrifid leaves are also found among the Hepaticae; none of our northern species, however, show a larger number of primary lobes than four. In the genus *Bazzania* the leaves are incubous, and in our commonest species, *B. trilobata* (*Fig. 10*), have three apical teeth. In *Lepidozia reptans* (*Fig. 11*), also with incubous leaves, the same stem will often produce both trifid and quadrifid leaves; the same is true of the succubous leaved *Lophozia barbata* and of other species of this genus. Here again gradations between bifid leaves and those just considered are also to be observed.

All of the leaves which we have so far noted are more or less flattened in one plane. The form of the leaves, however, is much more difficult to understand when the lobing is accompanied by folding. This condition is described as "complicate," the fold being called the "keel." We find it most frequently among bilobed leaves, which are then described as "complicate-bilobed." In these leaves the method of attachment is entirely different from what we have described above, each lobe being attached independently to the stem and the two lines of attachment meeting at an angle, which is sometimes very sharp. In the genus *Marsupella* (*Fig. 12*),

and in certain species of *Scapania* and *Sphenolobus*, the lobes are approximately equal in size, and the leaves ought not to be described as either incubous or succubous. In the majority of cases, however, where the complicate condition occurs, the lobes are unequal in size, the dorsal lobe being the larger in certain species and the ventral in others. In the Lejeuneae (*Fig. 13*), in *Frullania* (*Fig. 14*), *Radula* and *Porella* (*Fig. 15*), the dorsal lobe is the larger and the leaves are described as incubous: in many species of *Scapania* and in *Diplophylleia* (*Fig. 16*) the ventral lobe is the larger and the leaves are described as succubous. These conditions may also be best seen by diagrams (*Figs. 17–19*). In the genus *Ptilidium* the leaves are normally quadrifid and at the same time complicate, the keel occurring between the two middle divisions. In *Pt. ciliare*, which is one of the commonest and most conspicuous species in the eastern United States, the leaves are beautifully fringed on the margin; and this condition is carried to an extreme in the still more beautiful *Trichocolea tomentella*, where the leaves present the appearance of being divided almost to the base into an innumerable number of delicate hairs.

The leaves in many of the Hepaticae, through their arrangement, overlapping, lobing and folding, doubtless assist the plant materially in absorbing and retaining water. This is seen especially well in the two species just described, where the whole plant is practically permeated in all directions by capillary spaces, which can take up and hold water like a sponge. In certain genera this function is assumed by a definite part of the leaf, which becomes hollowed out and is know as the "water-sac." Among our northern genera this structure is best studied in *Radula*, in the Lejeuneae (*Fig. 13*), and in *Frullania* (*Fig. 14*). all of which, as noted above, are characterized by complicate-bilobed leaves, the dorsal lobe being the larger. In all these forms the water-sac is formed wholly or in part by the ventral lobe or, as it is often called, the "lobule," to distinguish it from the dorsal division of the leaf, called simply the "lobe." In *Radula* and in the Lejeuneae, the free edge of the lobule is closely appressed to the lobe except in the outer part, and the region of the leaf near the keel becomes inflated and acts as the sac, the water gaining entrance through the minute opening in the outer part where lobe and lobule are not in contact. In these cases both lobe and lobule enter into the formation of the water-sac. In *Frullania* a part of the lobule itself becomes hollowed out into a hood-like organ, open at one end and blind at the other; here the entire sac is formed by the lobule.

In comparison with the leaves the underleaves exhibit much less variety, as has already been noted. They are almost invariably transversely attached to the stem, the line of attachment being straight or nearly so; sometimes, however, they are decurrent, and the line of attachment becomes more or less arched. The latter condition is well seen in *Porella* (*Fig. 15*), where the decurrent base of the underleaf is sometimes longer than the free portion. Here again, as in the leaves, the simplest type is undivided, but the apex although sometimes broad and rounded as in *Archilejeunea clypeata* (*Fig. 13*), and in *Porella* (*Fig. 15*), is usually sharply pointed, the underleaf itself assuming a lanceolate or subulate form. These pointed

underleaves are very well seen in *Harpanthus* (*Fig. 20*), where they attain an appreciable size, but they are also to be found in many other species. They become more complicated when their margins are irregularly toothed or ciliate, as in many species of *Lophozia* (*Fig. 21*).

Variously lobed and divided underleaves are characteristic of many genera. In *Frullania* (*Fig. 14*) and in *Lejeunea* the underleaves, which are subrotund in form, are bifid, sometimes to beyond the middle. In *Lophocolea* (*Fig. 8*), *Chiloscyphus*, *Geocalyx* and other genera, the underleaves are much narrower, but are also deeply bifid. In *Lepidozia* (*Fig. 11*) the underleaves are broad and deeply trifid or quadrifid in the larger species. In *Ptilidium ciliare* and in *Trichocolea* the underleaves resemble the leaves in being strongly ciliate along the margins of the divisions. In none of our northern species, however, do the underleaves produce water-sacs, although this phenomenon occurs among certain antarctic genera.

It will be seen from what has been said so far that the leaves and underleaves afford generic characters of much importance. These are supplemented, in the purely vegetative part of the plant, by characters derived from the branching and from the cell-structure; but, as it is difficult to discuss these without entering into considerable detail, we may pass at once to characters connected with the reproduction.

The antheridia and archegonia of the scale-mosses are essentially like those of the true mosses. The archegonia are borne singly or in groups on the tips of specialized branches, the growth of which is thereby terminated. As a rule only one archegonium of a cluster develops a sporophyte. Even in the absence of fertilization, the archegonial branches yield important characters. Instead of being prostrate such branches tend to be ascending or erect, and their leaves are oftentimes very different in appearance from the ordinary vegetative leaves. These leaves are called "bracts," and the corresponding underleaves "bracteoles." In many cases the latter are nearly or quite as large as the bracts, and this is true of some species which lack underleaves on ordinary stems. In a number of species which are destitute of underleaves, bracteoles also fail to be devoloped. The various species of *Radula* are striking examples of this condition. As a rule the bracts are less highly specialized or less definite in their characters than the leaves. In a species with bifid leaves, for example, the bracts tend to be irregularly two-to four-lobed (*Fig. 22*); in a species with well-developed water-sacs these structures are not developed on the bracts (*Fig. 23*): in certain species with undivided leaves, the bracts are bifid. In still other cases the bracts are scarcely to be distinguished from the leaves. Usually the archegonial branch shows a gradation between typical leaves and typical bracts.

The archegonia, the young sporophyte and the calyptra cannot be seen as a rule without careful dissection. This is because they are covered over and concealed by other parts of the plant, and are apparently thus protected from being dried up. In very rare cases, the covering is done by the bracts alone. Usually, however, in addition to the bracts, the archegonial branch bears a remarkable tubular organ called a "perianth," or else itself develops into a hollow structure known as a "perigynium."

The perianth is an organ peculiar to the scale-mosses, although not found in all of them. In the majority of our species it develops whether fertilization takes place or not; in a few species, however, its development depends upon fertilization. In no case does the development of the perianth precede that of the archegonia. The perianth consists of a hollow tube, which is attached at the base and open at the tip, sometimes with a wide mouth. Under normal circumstances it surrounds the young sporophyte and assists the calyptra in protecting it (*Fig. 24*). Most writers look upon the perianth as a structure formed by the coalescence of leaf-like organs, and it differs in appearance according to the number and character of the leaves which enter into its formation. In the simplest case it is formed by the union of two leaves and one underleaf, which remain flat. This gives rise to a perianth in the form of a triangular prism, three angles or keels being formed by the united edges of the leaves. If we suppose that such a perianth is pressed back against the substratum, two of the keels will be lateral and the third will be dorsal. This type, which is known as "epigonianthous," is beautifully shown in the genus *Lophocolea*, and may be represented in cross-section by such a diagram as *Fig. 25*. In case no underleaf takes part in the formation of the perianth, we observe a structure which is compressed at right angles to the substratum, a condition found throughout the large genus *Plagiochila* (*Fig. 26*). A very different type of perianth arises when the leaves which enter into its formation are complicate instead of being flat. In this case the keels of the leaves usually form keels on the perianth, and when a triangular perianth is formed, the third keel instead of being dorsal will be ventral. This condition, called "hypogonianthous," is found with certain modifications in a large number of genera, of which *Frullania*, *Lejeunea*, *Porella*, *Cephalozia*, *Bazzania* and *Lepidozia* may be especially mentioned (*Fig. 27*). When no underleaf takes part in this type of perianth, we again observe a compressed structure, but this time the flattening is parallel to the substratum instead of at right angles to it (*Fig. 28*). This condition is found in the genera *Radula* and *Scapania*. In many species the structure of the perianth is obscured, either by the obliteration of keels or by the interpolation of additional keels, and under these circumstances the interpretation becomes much more difficult.

The perigynium, unlike the perianth, is formed directly from the archegonial branch. It occurs in comparatively few genera, and its development is always dependent upon fertilization. While the sporophyte is growing, the archegonial branch which bears it begins to grow also in the form of a hollow tube. This encloses the young sporophyte and carries up on the outside the bracts and bracteoles. In some cases, as in *Nardia* and *Marsupella*, the perigynium bears a perianth at its mouth (*Fig. 29*). In other cases, as in *Gymnomitrium*, there is no perianth formed. In the examples so far considered the perigynium has grown in an upward direction only: in other cases, however, it grows downward as well, and sometimes its growth is entirely downward. The first of these conditions may be seen especially well in *Nardia haematosticta*, the second in *Geocalyx* and *Kantia*, the perigynium in these two genera being in the form of a pendent sac (*Fig. 30*),

which penetrates into the substratum and thereby protects the sporophyte still more effectively. With this type of perigynium the perianth is almost invariably absent.

The characters noted above are usually sufficient to distinguish the genera of the Jungermanniaceae. The antheridial branches and the sporophytes occasionally yield additional characters of interest. Both of these structures, however, are likely to be uniform or nearly so throughout large groups of genera, and their characters, therefore, are more frequently tribal or even ordinal in value rather than generic. Under the circumstances it is hardly necessary to discuss them at the present time. YALE UNIVERSITY.

ADDITIONS TO THE BRYOPHYTIC FLORA OF WEST VIRGINIA.

A. LEROY ANDREWS.

The "Preliminary Catalogue of the Flora of West Virginia," published by Dr. C. F. Millspaugh in 1892 (W.Va. Exp. Stat. Bull. No. 24, pp. 311-537), contained a list of eighty-three species and varieties of mosses and twenty-seven of hepatics, collected at a few points, mostly in the vicinity of Morgantown, in Monongalia County. A flora of the state embodying the results of later collections was published by Dr. Millspaugh in collaboration with Mr. L. W. Nuttall, who had made extensive collections and studies about Nuttallburg, in Fayette County (Publications Columbian Field Museum, Bot. Series, Vol. 1, pp. 65-276, 1896). In this list were noted six additional species of mosses and five of hepaticae. For both lists, as is explained in the introduction to the latter, the bryophytes had been gathered spasmodically and incidentally to the investigation of other plants.

I have seen two papers of later date listing additions to the West Virginia flora, viz.: "Some Plants of West Virginia," by E. L. Morris (Proc. Biol. Soc. Wash., Vol. XIII., pp. 171-182, 1900), and "Some New and Additional Records in Flora of West Virginia," by C L. Pollard and W. R. Maxon (Proc. Biol. Soc. Wash., Vol. XIV., pp. 161-163, 1901). Of these the former mentions two additional hepaticae and four mosses, two of which are included in the previous lists. The latter includes as new, two hepatics and seven mosses, one a repetition from the preceding paper.

From collections made mostly during the fall of 1903 and spring of 1904 in the vicinity of Morgantown I am able to add the following. Those recorded from near Masontown are from Preston County: the others, unless expressly stated, from Monongalia County. The region of Chestnut Ridge was most productive in bryophytes, the territory westward being very poor in species. Chestnut Ridge enters West Virginia from Pennsylvania, its direction slightly southwesterly, its altitude approximately 2,000 feet, and represents, so far as Pennsylvania and northern West Virginia are concerned, the extreme western ridge of the Allegheny system. East of Morgantown this ridge is cut by the valleys of Decker's Creek and the Cheat River, and the richest collecting grounds are along the mountain streams tributary to these rivers. Especially are the steams descending the western side of the ridge characterized by rapid falls and the presence in their beds of many